



## Case report

# Autopsy practice in forensic pathology – Evidence-based or experience-based? A review of autopsies performed on victims of traumatic asphyxia in a mass disaster



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## ABSTRACT

Current autopsy practice in forensic pathology is to a large extent based on experience and individual customary practices as opposed to evidence and consensus based practices. As a result there is the potential for substantial variation in how knowledge is applied in each case. In the present case series, we describe the variation observed in autopsy reports by five different pathologists of eight victims who died simultaneously from traumatic asphyxia due to compression during a human stampede. We observed that there was no mention of the availability of medical charts in five of the reports, of potentially confounding resuscitation efforts in three reports, of cardinal signs in seven reports and of associated injuries to a various degree in all reports. Further, there was mention of supplemental histological examination in two reports and of pre-autopsy radiograph in six reports. We inferred that reliance on experience and individual customary practices led to disparities between the autopsy reports as well as omissions of important information such as cardinal signs, and conclude that such reliance increases the potential for error in autopsy practice. We suggest that pre-autopsy data-gathering and the use of check lists specific to certain injury causes are likely to result in less deviation from evidence-based practices in forensic pathology. Pre-autopsy data-gathering and check lists will help ensure a higher degree of standardization in autopsy reports thus enhancing the quality and accuracy of the report as a legal document as well as rendering it more useful for data-gathering efforts.

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## 1. Introduction

In forensic medicine, the detection of single findings has often been of great significance in establishing the cause of death. For this reason, empiricism has become an important and much used method to achieve knowledge. As in all other medical fields, empirically gained knowledge must be tested either by analysis of important case series or by experiments in order to meet the requirements for conducting evidence-based medicine. This transition from observation to evidence is not always easily made, but it is a necessary process to go through to validate the empirical findings and assure the quality of forensic scientific evidence.<sup>1</sup>

One of the obstacles to obtaining evidence-based scientific argumentation is that autopsy practices to a large extent are based on individual customary practices and knowledge. This kind of experience-based practice makes inference on causal mechanisms difficult. There exists a broadly accepted need to incorporate more evidence-based practices in forensic pathology.<sup>1–5</sup> This need is balanced by the common perception that “no two cases are alike in forensic medicine” and the challenges of applying traditional medical study designs to a forensic setting. In Denmark, as in many other western countries, little systematic research has been conducted to validate the basic premises and techniques used in many areas of forensic medicine.<sup>4</sup>

The variation in autopsy practices is difficult to quantify because of the diversity in the clinical presentation of the cases seen in forensic pathology. This obstacle to the evaluation of autopsy practices is lessened in the rare setting of multiple deaths resulting

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from the same cause at the same time. Such an occurrence affords some insight into the variability of individual autopsy practice in a semi-controlled setting.

In this paper we describe a case series of autopsies performed on multiple victims who died at the same time, at the same event and from similar injury mechanisms. All the victims were autopsied within hours of each other by five different pathologists and the autopsies were all supervised by the same senior pathologist. We describe the similarities and disparities between the resulting reports, and examine the disparities from the context of how a more systematic approach, such as pre-autopsy data-gathering or the use of check lists, may have improved the thoroughness and accuracy of the final autopsy report.

## 2. Background

One evening in June, 2000, a rock concert took place at a music festival in Denmark at which nine concert guests died in a human stampede. Approximately 50,000 concert guests had assembled to attend the concert and when the band began playing, a continuous flow of concert guests combined with aggressive forward seeking behaviour in the crowd created forceful wave movements in the audience. These movements caused a group of approximately 50 concert guests standing in front of the stage to fall on top of each other. The crowd was so densely packed that the fallen were unable to get up and attempts to help were futile. The music was stopped about 20 min after the concert guests fell and it took an additional seven minutes to get the crowd to pull back from the stage so that the fallen could be helped and brought to medical treatment. Some of the fallen concert guests were without vital signs and despite intense resuscitation efforts, five were declared dead on scene and three others upon arrival at a nearby hospital. The last victim survived initially and was submitted to an intensive care unit where he was pronounced dead five days after the stampede.<sup>6</sup>

The eight victims who died initially were all autopsied the following day at our department by five different pathologists. All autopsies were supervised by the same senior pathologist who also read and co-signed all eight autopsy reports. The cause of death in all cases was determined as traumatic asphyxia due to compression of the thoracic wall. Eight separate autopsy reports were written and served as documentation of the incident and for the further investigation. The victim who died five days after the stampede was not autopsied because the police did not request a medico-legal autopsy.

### 2.1. Traumatic asphyxia

Traumatic asphyxia is caused by a trauma to the thoracic wall and/or the upper abdomen inhibiting respiratory movements. Mechanisms include entrapment of the thoracic cage (positional asphyxia) and blunt trauma causing splinting of the thoracic cage and/or the diaphragm but without continuous compression (crush asphyxia). Common causes are motor vehicle crashes and industrial and farming incidents.<sup>7</sup> In human stampedes traumatic asphyxia is one of the most common causes of death.<sup>8</sup>

The three cardinal signs of traumatic asphyxia are cervico-facial congestion and cyanosis, conjunctival haemorrhage and cutaneous petechiae. These findings are believed to be related to an increase in intrathoracic pressure transmitted by the compressing force. The compression causes retrograde blood flow in the valveless intrathoracic veins, and in the presence of a continued arterial blood supply, the cephalic venules become dilated with desaturated blood which produces the congestion and cyanosis. Ultimately the venules burst thereby producing the characteristic petechiae which are most prominent in the conjunctivae and palpebrae, where the connective tissue surrounding the venules is least supportive.

In addition to the cardinal signs, several other associated injuries can be seen depending on the force of the trauma. These include cutaneous lesions such as haematomas, excoriations and contusions, fractures of especially costae, clavicles and sternum, submucosal petechiae on the larynx, trachea, subepicardium, epicardium, pleura and brain, pneumothorax, contusions and lacerations of both intrathoracic and intraabdominal organs and acute pulmonary emphysema.<sup>7,9–15</sup>

In the present case the pathologists were informed by the police prior to the autopsies that the victims were crushed to death as witnessed by hundreds of concert guests. Hence the purpose with the autopsies was to establish the degree to which this information correlated with the autopsy findings.

## 3. Material and method

Autopsy reports as well as supplemental reports on toxicology and histology results were retrieved from our database at the department and were read through by pathologists with clinical experience in forensic pathology varying from 2 to 17 years. No autopsy or supplemental reports were excluded or missing from the search.

## 4. Results

### 4.1. Availability of information prior to the autopsy

All eight autopsy reports stated that a police report was available prior to the autopsy. Three reports stated that emergency room (ER) medical charts were available, while the remaining five reports had no comments on the availability of such charts. Two reports stated that cardiopulmonary resuscitation (CPR) had been performed, three reports described findings of CPR equipment (airway tubes, electrodes, pads and venflons) on the body indicating that CPR had been performed while the last three reports did not mention whether CPR had been performed or not. None of the reports commented on availability of past medical records from the general practitioner.

### 4.2. Autopsy report findings

Autopsy report findings are summarized in Table 1. All eight victims were male and the median age was 22 years (range 17–26 years). Median height was 179.5 cm (range 167–186 cm) and median weight was 78.5 kg (range 65–97 kg). Conjunctival haemorrhage and cutaneous petechiae were commented upon in all eight autopsy reports either as a positive or negative finding. The cardinal sign, cervico-facial cyanosis and congestion, was only commented upon in one report, in which it was a positive finding. The remaining seven reports had no mention of this sign either positively or negatively. All but one victim had conjunctival haemorrhage, six had cutaneous petechiae while facial cyanosis thus was only noted in one victim.

Cutaneous injuries and fractures were commented upon as a positive or negative finding in all eight autopsy reports; all victims had cutaneous lesions such as abrasions, haematomas or contusions while only one victim had a fracture (a single rib fracture). Pneumothorax was commented upon as a negative finding in seven reports and not found in any of the victims. Acute pulmonary emphysema was commented upon in five reports and found in four victims, lung contusion was commented upon in four reports and found in two victims, heart contusions were commented upon in one report and not found in any victims, pleural submucosal petechiae was commented upon in three reports and found in three victims while epicardial submucosal petechiae was commented upon in six reports and found in six victims. Furthermore, one

**Table 1**  
Autopsy report findings.

Entity	Actual number (-/8)	Mentioned in report (-/8)	Not mentioned in report (-/8)
Police report	8	8	0
Emergency room medical charts	3	3	5
Cardiopulmonary resuscitation	5	5 <sup>a</sup>	3 <sup>a</sup>
Past medical records	0	0	8
Full body radiography	8	6	2
Histology	2	2	6
Toxicology	8	8	0
<b>Cardinal signs</b>			
Conjunctival haemorrhage	7	8	0
Cutaneous petechiae	6	8	0
Cyanosis/congestion	1	1	7
<b>Associated injuries</b>			
Cutaneous lesions	8	8	0
Bone fracture	1	8	0
Pneumothorax	0	7	1
Acute emphysema	4	5	3
Lung contusion	2	4	4
Heart contusion	0	1	7
Pleural petechiae	3	3	5
Epicardial petechiae	6	6	2
Aspiration	1	8	0
Organ congestion	3	8	0

<sup>a</sup> Only two reports stated that cardiopulmonary resuscitation (CPR) had been performed. However, three other reports described CPR related equipment on the body thereby indicating that CPR had been performed.

victim had aspiration of gastric content. Six autopsy reports described congestion of organs (brain, thoracic and/or abdominal) as associated injuries.

No photographs were taken in conjunction with the autopsies.

#### 4.3. Supplemental examinations

Six autopsy reports stated that a full body conventional radiograph of the victim had been performed prior to the autopsy, while the remaining two reports had no mention of such examination having been performed.

Histological examination was performed in two cases; in one case tissue from the lungs, liver and heart were examined and in the other case tissue from the lungs and liver were examined. In both cases the examination showed congestion of the lungs and fatty liver. Histological examinations were not performed in the remaining six cases.

In all cases a toxicology screen was performed which included screening for heroin/morphine, cannabis, benzoylecgonine (cocaine metabolite), amphetamine and 3,4-methylenedioxymethamphetamine (ecstasy). All the victims were negative for all drugs. Blood alcohol was positive in all eight victims and ranged from 3.18 mg/dl to 178.08 mg/dl (median 72.08 mg/dl).

#### 4.4. Cause of death

All eight autopsy reports concluded that the presumptive cause of death was traumatic asphyxia due to compression of the thoracic wall. In one report suffocation due to aspiration of gastric content was mentioned as a possible contributory factor to the cause of death. None of the autopsy reports included a deliberation on to what extent the observed lesions might have been caused by the trauma as opposed to CPR efforts.

### 5. Discussion

It is the responsibility of the police to obtain and provide necessary medical and legal documents to the pathologist prior to

the autopsy. In an acute setting however, such documents are not always readily available simply due to little timespan between death and autopsy. Under such circumstances, it is customary practice to mention not only which documents were available prior to the autopsy, but also which relevant documents were not available. Injuries resulting from efforts to resuscitate, including ventilation and chest compression, can mimic signs of traumatic asphyxia. Petechial haemorrhages on the facial skin, eyelids and conjunctivae have been described as result of CPR as well as bruising and abrasions in the face and neck area, pulmonary barotraumas, aspiration of gastric contents, rib fractures, epicardial petechiae and lesions of the heart.<sup>16,17</sup> Since the observed lesions could have been caused by both the crush trauma as well as efforts at resuscitation, it would have been relevant to note in all the autopsy reports whether information on CPR efforts was available or not and in case of availability, whether CPR efforts had been performed or not. In the case described in this paper, the police was present during the autopsies and most likely could have supplied oral information on CPR efforts for each victim.

Only one autopsy report mentioned all three cardinal signs, noting that they were all present.

Conjunctival haemorrhage and cutaneous petechiae were commented upon in all eight reports, and it thus appears that facial cyanosis and congestion was systematically overlooked. The associated injuries that were most frequently commented upon both positively and negatively were cutaneous lesions, fractures and pneumothorax. This could, in part, be attributable to cutaneous lesions being a positive finding in all victims and that all eight victims received a full body conventional radiograph, which was evaluated for fractures. Additionally, the standard operating procedure for opening of the chest wall included doing so under water in order to evaluate pneumothorax. Pleural and epicardial petechiae were only noted when they were a positive finding while acute pulmonary emphysema and contusions of the lungs and heart were predominately noted as positive findings. It thus seems that unless standard operating procedures implied a certain investigative measure, mostly positive findings were noted while relevant negative findings to a larger extent were unmentioned upon.

The role of histological examination in forensic autopsies is a subject of debate in terms of the need of maintaining a high volume of histology countered by a call for a more rationalized evidence-based approach.<sup>18,19</sup> Molina et al. found that in 189 routine forensic cases, in only one case did histologic examination affect the cause of death and in no case did it affect the manner of death. The authors concluded that although histological examination is of value in certain cases, it cannot be expected to affect cause or manner of death to any significant level in cases where cause and manner of death are determined by gross examination.<sup>19</sup> However, we find that histological examination can be of relevance in identifying disease that is not necessarily detected by gross examination and that could have been contributory to the cause of death, e.g. inflammatory lung disease or emphysema. Histological examination should therefore have been performed uniformly in all cases not only with the aim of standardizing the autopsy reports, but also to ascertain the accuracy of the presumptive cause of death.

In one case suffocation from aspiration of gastric contents was stated as a possible contributory factor to the cause of death. This finding was obtained by gross examination and not verified histologically which renders it an uncertain finding.

Toxicological screening is relevant as the level of intoxication with alcohol, medicine or drugs can influence the victims' ability to both identify danger as well as extract themselves from a dangerous situation. Intoxication therefore becomes a possible contributory factor to the cause of death and should, as it was, be assessed in all cases.

Despite the described dissimilarities between the cases, the cause of death was stated as traumatic asphyxia due to compression of the thoracic wall in all cases. All eight autopsies were supervised by the same senior pathologist who also co-signed all the autopsy reports. We have no reason to believe, that the dissimilarities were purposely neglected or deliberately ignored when the conclusion on cause of death was made. In our opinion, it is more likely that the information on trauma mechanism (crushed in a human stampede) given by the police prior to the autopsies have been given more weight by the pathologists than the actual autopsy findings. Additionally, no findings indicative of a competing cause of death was found in any of the victims, which might have strengthened the assumption that death was caused by traumatic asphyxia.

This case series showed a high degree of variability in autopsy practices in a setting where one might expect little variability due to highly similar case circumstances in autopsies performed simultaneously in the same forensic department. This variability not only lessens the quality of the autopsy report as a legal document but also render it less useful for research purposes. There have been several attempts to design unified protocols for forensic autopsies but our case series show that the need for such protocols, or the implementation of already existing protocols, is not exhausted.<sup>20,21</sup> We suggest, when applicable, the design and use of case specific autopsy guidelines on the level of the single, forensic department with the intention of achieving a uniformed national use of these guidelines. Such guidelines should be based on current, peer-reviewed literature and already existing guidelines and could very well take on the form of check lists, which have been proven useful in many other areas of medicine.<sup>22–24</sup> In forensic pathology, check lists might be utilized in well-defined cases such as traumatic asphyxia due to compression, drowning or carbon-monoxide poisoning in assisting the pathologist in adhering to key signs and which supplemental examinations should be performed.

But check lists might also be useful in a broader context e.g. as an entry point to autopsies in assessing when, pursuant to the case in hand, it is necessary to perform pre-autopsy data-gathering from institutional databases, peer-reviewed journals or standard forensic textbooks in preparation for the autopsy. Typically, the use of forensic textbooks would be sufficient, but in more atypical or infrequently encountered case types the use of textbooks should be supplemented with a search for peer-reviewed literature. A search in our department database showed that only 11 autopsies of victims of traumatic asphyxia due to compression had been performed before this case series. Because the putative mechanism of death was unusual in these cases it is less likely that the individual pathologist would have a “customary” approach to investigating the cause of death in suspected traumatic asphyxia cases. Thus, the present case series stands as a good example of circumstances in which it may have been helpful to supplement pathologist knowledge and experience with a check list and a literature search or reference to standard texts.

## 6. Conclusion

The unique nature of the cases described herein offered an opportunity to appraise the variability among individual autopsy practices. This appraisal demonstrated a number of important disparities and omissions in the autopsy reports attributable to variation in customary practices and how knowledge is applied by the individual medical examiner. These disparities and omissions lessen the thoroughness and accuracy of the autopsy report rendering it less useful as a legal document and for future research

purposes. We suggest, pursuant to the case in hand, that pre-autopsy data-gathering from standard textbooks, peer-reviewed papers and/or institutional databases, combined with the use of check lists, may provide a more proper evidence-based setting for performing an autopsy, thus ensuring a greater level of standardization and ultimately enhancing the quality of the autopsy report. Such changes are currently being implemented in our department and will be evaluated after implementation.

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None.

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### Conflict of interest

The authors declare that they have no conflict of interest.

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